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THE SURGICAL TECHNIQUE

OF

ASEPTIC WOUNDS.

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The Surgical Technique of Aseptic Wounds.

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THE SURGICAL TECHNIQUE OF ASEPTIC WOUNDS.

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Notwithstanding the revolution already wrought in the technique of wound treatment, I must yet think that no subject more important or practical can be brought before the profession at the present.

Wound infection, in a general way, is fairly well understood, and those who have given special attention to the subject will, at least in a large degree, accept the opinion which I published some years since, that suppuration, supervening in a wound, deliberately made by the surgeon, through healthy integuments, indicates that there has been some avoidable error in its technique. If the conscientious surgeon accepts this view as the standard by which to criticise his work, and earnestly seeks to determine the cause of the error, he will find a gradual elimination of much that is superfluous, as well as defective in detail. For the scientific skillful surgeon a bacteriologic training is almost a *sine qua non*, since only by such repeated investigations is he enabled to familiarize himself with the special characteristics of the infective material with which he has to deal.

The reparative processes, supervening in the well vitalized tissues of the healthy animal, non-infected by bacteria, are comparatively simple. The necrosis line following a clean incision may be limited to the injured cells, and only a microscopic layer of tissue is involved in the changes which ensue in the impeded surrounding circulation, local stasis, and exu-

dation of lymph. Beyond the line of the exuded lymph which glues the two surfaces together, the changes are very limited, an infiltration of leucocytes and plasma cells supervene, connective tissue cells develop, and a permanent union of the structures is effected. Upon the cutaneous surface the epithelial cells interblend, and this process of healing, even in wounds of considerable size, may go on almost without constitutional disturbance, pain, or edema.

In wounds of important structures and of considerable extent, there is generally a prompt reaction, exhibited by a considerable, more or less, rise of temperature, which is explained probably by the reflex disturbance of the nervous centers. Within limit this may be regarded as a favorable reaction, since within twenty-four to thirty-six hours the temperature falls without serious constitutional disturbance. This must not, however, be confounded with the fever due to septic infection, which usually does not make its appearance until after the third day.

If, on the contrary, the divided structures are not brought into apposition, the space is filled with coagulated blood and serum, and the repair processes become far more complicated. The aseptic blood clot is penetrated by leucocytes and proliferation cells, and, little by little, an organized structure extends through the mass, the so-called healing by blood clot supervenes, which is to say that the regenerative processes, observed in the first instance, take place much more slowly, but effectually utilizing the aseptic blood clot by a metamorphosis of its material in part, and in part by absorption. If in addition to the blood clot we have introduced into the wound a bacterial infection, entirely another class of conditions supervene, dependent upon the character of the infective material. If the wounds are large with much effusion, owing to the development of the bacteria, the blood becomes rapidly decomposed and a large amount of chemic poisoning is produced, the so-called toxins which are absorbed causing a kind

of septic intoxication, varying in degree, but which may speedily prove fatal.

In a paper of this limit it is possible to refer only with extreme brevity to the character of the micro-organisms with which the surgeon has specially to deal. Fortunately there is less necessity for the description of these organisms than at an earlier period. The staphylococcus pyogenes aureus and albus and the streptococcus pyogenes are almost the only organisms which produce suppuration. The staphylococci in their development produce the typical local suppuration, while the streptococci possess the property of invading the tissues and are, as a consequent, oftentimes eliminated with much greater difficulty, causing the acute forms of septicemia and pyemia. Other varieties of microörganisms not seldom develop in wounds, especially the putrefactive bacteria and although their organisms can not penetrate into, or reproduce in, the structures, the toxins which they produce may cause very serious constitutional disturbances. The developing cocci induce a rapid liquifaction of the albuminoids and thus break down the blood clot, and organizing lymph. Thus the toxic chemic material evolved in their growth may act as a local poisoning, devitalizing the surrounding structures, producing coagulation-necrosis. In the surrounding structures a complex process supervenes owing to this toxin infiltration, causing the so-called processes of inflammation, dwelt upon at great length by the earlier writers. There is much yet to be learned in reference to the changes which ensue about the infected wound structures, and from this standpoint the whole subject of wound inflammation needs to be rewritten.

The streptococci extend along the lymphatic vessels and lymph spaces and, when introduced into the blood, growing as they do in long chains, they have a tendency to form emboli in the smaller vessels, and thus set up new centers of suppuration at very considerable distances from their original seat of inva-

sion. On the contrary, the staphylococci, developing locally are soon surrounded by a living wall of leucocytes, which impede the further dissemination of the invading enemy, and the contest goes on *in loco*, and the result of the battle will depend upon the vigor of the antagonists. Hence the practical importance, which must always be apparent, that the surgeon devitalize as little as possible the tissues in operative interference. It is indeed well known that it does not of necessity follow that a few microörganisms thus introduced will reproduce to the detriment of the individual; the superior vitality of the tissues may enable them to destroy their enemies *in loco*, and the processes of primary repair may go on uninterruptedly.

How a certain limited number of microörganisms can be destroyed in a wound, is a question of intense interest which can not be discussed here, beyond the fact that a phagocytic action of cells does supervene under certain favorable conditions and the bacteria fail of development. Of course, much depends upon the vitality of the surrounding structures and the non-presence of the proper pabulum or soil for bacterial growth. It is a fact that any considerable blood clot in the wound infected by developing bacteria prevents primary union.

Inferences of practical importance are clearly drawn from the above facts in regard to the manipulation of wounded structeres. Let all incisions be cleanly made with a very sharp knife, avoid the still too common practice of seizing and holding considerable portions of tissue with compression-forceps for the arrest of hemorrhage. Protect the structures carefully from tearing in the separation of wounds, as, for example, in the use of retractors in laparotomy, and perhaps more important than all, be careful in the adjustment and coaptation of like structures when suturing in the closure of wounds.

It is no excuse, however, for careless surgery that bacteriologic demonstrations show that a few bac-

teria, even of the pathogenic varieties, when planted in healthy tissues, may fail to reproduce, although this is the probable explanation why some of the so-called "clean surgery" well performed without rigid aseptic precautions is not rarely followed by primary union.

Just at present, the profession is undergoing a transition state by the more or less general acceptation of the influence and power, which certain chemic substances, the so-called toxins produce. Blood serum affected by these is believed, upon that which many accept as good authority, to possess an inhibitory power to prevent in some way the development of the bacteria within the organism. It seems very probable that this fluid in the healthy body is far more potent in the protection of the individual from the invasion of bacterial enemies than was earlier supposed.

The military student may well profit in his studies of defensive warfare from a careful investigation of the wondrous way which nature has in defending her outposts from the invasion of bacterial enemies.

The thoughtful investigator makes the inquiry, wherefrom come these invisible hordes which endanger the individual at every infraction of surface? The aerial ocean in which we live and of which we must ever breathe is, it is true, rarely without deleterious bacterial organisms, but by general consensus of opinion, based upon abundant demonstrative evidence, these organisms are much less potent for ill in surgery than was earlier believed, and it is not less certain that the all-invading bacteria, contaminating clothing not worn upon the person, and water as usually found in hydrant service contain less dangerous elements than was at first supposed.

It is due in large measure to the very valuable experimental researches, carried on in the bacteriologic department of the Johns Hopkins University, that we have the most important demonstration that the all-pervading source of the pyogenic bacteria is found

in the dead and dying epithelial cells. Indeed, it appears that nature with a rare temerity has subjugated this all common enemy and drafted it into her service for the purpose of removing the no longer serviceable plates of the armor with which the organism is clothed and protected. Within certain limits these invisible agents are permitted to riot and with insatiable avidity seize upon every dying epithelial cell, the demarcation line existing in the cell whose inherent organic power is greater than that of the overlying enemy. Hence the surgeon finds at the very door the ever-lurking foe, and the problem of their destruction is of comparatively easy solution with the abundant agencies which are at his command. For the destruction or removal of the bacteria invading the skin, antiseptic measures are of the greatest advantage and even necessary. In their use we find the easy explanation of the seeming difficult question of the good results obtained from different methods. One operator cuts short the finger-nails, soaks and scrubs with hot water and soap, until by a process of maceration he has loosened and detached the infected epithelial cells, and stands out as the bold apostle of cleanliness, having demonstrated, as he thinks, that soap and water are sufficient.

Another repeats the experiments of the early great master, Mr. Lister, and declares that the maceration of the skin of the patient, for some hours, with a watery solution of carbolic acid, is ample. Thus the cleansing process has been varied by the use of many substances, to each of which has been ascribed the protective power. To all this questioning and experience the laboratory investigation gives the one definite answer, By some means remove or destroy the loosened, worn-out, epidermal cells. The demonstration seems conclusive that the great enemy to all surgery, the hand of the operator, is best disinfected as first taught in Baltimore, by the use of solutions of permanganate of potash and oxalic acid.

If it be true, that permanganate of potash in solu-

tion does not color the living cell, and that all devitalized epidermal structures are invaded with pyogenic cocci, then the demonstration is ample, that the hands of few surgeons, relying only upon the ordinary processes of washing with soap and water, are likely to be surgically clean. These epidermal cells, however, may remain so adherent even after the processes of washing and scrubbing have been thoroughly practiced, that a prolonged operation may not cause their loosening and transplantation into the operative wound.

From these investigations we also have the knowledge of the more usual forms of contamination found in hospitals and the ordinary bed-chamber. Proliferating epithelium of the skin becomes disseminated and may prove a source of contamination through the infection of both the air and water. In this way instruments, sponges, and clothing are generally infected.

From the above it is easy to determine why the older forms of wound dressing were so invariably productive of suppuration; the bacterial development went on under the watery dressings and especially poultices, these proving hot-beds of infection.

The destruction of pathogenic bacteria during their period of rapid development is comparatively easy. Moderate changes of temperature affect their growth, and various chemic substances, even in weak solutions, produce their death, but those varieties which reproduce by spores are among the most resistant of living organisms. Exposure at the freezing point, immersion in boiling water for a considerable period often have little effect, but fortunately the surgeon very rarely has to deal with the spore-producing forms of bacteria. All the pyogenic cocci do not reproduce by spores; were it not for this fact it would seem almost hopeless to adopt methods of wound treatment which could successfully prevent the most fatal consequences, such as would follow were their common enemies of a type of which an-

thrax, tetanus, and tuberculosis may be cited as examples. But here also we find the knowledge of the life histories of these comparatively recent known enemies to mankind most valuable, since the spore producing bacteria are of much slower development which renders it easier for the wounded organism to resist their depredations. Comparatively weak solutions of bichlorid of mercury from 1 to 1000 or 2000 or a 2 to 5 per cent solution of carbolic acid are ample to destroy the pyogenic cocci, if the exposure is complete. These pus-forming agents, however, are quite completely protected by the fatty products of the sweat ducts, unless the watery solutions are for a very considerable period retained upon the skin. This is especially true of the mercuric solution, probably the most efficient antiseptic agent in general use, since the power of penetrating the epithelial cells is far less than that of carbolic acid. Hence in skin disinfection we note the importance of soap, alcohol, ether, turpentine, etc., as valuable adjutants.

The only class of wounds which this occasion affords the opportunity for discussion is that in which the surgeon is enabled to operate through previously unbroken, undevitalized, superficial structures, and where the wounded parts can be brought into complete approximation. Theoretically under such conditions primary union must ensue, and where this fails from the occurrence of suppuration, as I stated in the beginning of this paper, there has been some fault in the technique. The rule prevails in the treatment of the structures after they have been submitted to surgical interference in precisely the same formula as tersely stated for the treatment of a simple fracture, *fixation*, *retention* and *rest*, and as in a simple fracture the wounded structures must be without septic infection.

This naturally leads to the discussion of the terms aseptic and antiseptic, used with confusion, without a correct appreciation as to their meaning, and perhaps it would be better if both terms were entirely

discarded. The problem is to make and maintain a wound without infecting the structures involved. This surely should leave the parts *aseptic*, that is free from pyogenic organisms.

In order to do this, it is equally clear that the circumfusa of the wound, the instruments, sponges, suture material, and hands of the operator must be free from septic organisms. To effect this the various means at our disposal, by which we sterilize the materials in use may still be called *antiseptic*, the name first given to these processes by the great master of modern surgery. I have already entered into the discussion of the infective bacteria as much as the time at my disposal permits, sufficient indeed to point out their danger. Important practical deductions from this teaching are comparatively simple, but most definite in character, and, although there will probably remain yet an infinity of variation as to detail, the great fundamental principles of this class of wounds and their treatment may be considered settled. First, and most important is the disinfection of the skin of the patient and of the hands of the operator. It will be remembered that the cocci growing in the skin penetrate as deeply as the devitalizing processes of the epithelial cells; that the sebaceous and hair follicles are yet more deeply invaded, and that they are here protected from destruction to a certain extent by the glandular and fatty products.

It seems almost superfluous to refer to careful experiments, often repeated, which show that soap and water, applied with the minutest care fail to disinfect the glandular structure of the skin, and, if this is true, although these measures are of the greatest importance, the processes of so-called simple cleanliness are not sufficient. Therefore we must call to our aid some of the various antiseptic agents long since proved trustworthy. The first of these is carbolic acid, objectionable because of its irritating character. It is found, however, that this very irritation of

the skin is owing to its penetrating power upon the epithelial cells, and the glandular structures. It has an affinity for oily products and easily impregnates fatty substances. In this respect it is much more efficient than even considerably strong solutions of corrosive sublimate, but in the glandular and hairy portions of the body even the .5 per cent. solution of carbolic acid must remain in contact for a considerable period to disinfect these portions. For this purpose a 10 per cent. solution of oxalic acid is far more trustworthy. Cultivations made from the scrapings of the skin after having been treated carefully with oxalic acid solutions show the epithelial *débris* to be invariably sterile, even when the material to be tested is taken from the deep folds of the finger nails.

The use of the razor is important even where there is comparatively little hair to be removed. The repeated soaping of the parts softens and loosens the epithelium, which the scraping of the razor easily removes. To the soap, carbolic acid and bichlorid of mercury may be profitably added. If possible, these details should be carried out before etherization, because of the saving of time and the more thorough manipulation permitted when haste is not demanded.

Instruments are easily disinfected by heat, which is preferable to immersion in disinfectants, since the damage to the instruments is less than by a considerable period of immersion in antiseptics.

The preparations thus far completed, it now remains properly to protect and care for the patient in order that, during the operation, the surroundings of the parts to be operated upon may be also sterile. This is best effected by packing about with towels sterilized by heat, or by immersion in antiseptic fluids. I prefer the latter, towels wrung from a solution of 1 to 1000 of bichlorid of mercury, since they remain in position much better when wet than dry. It is also important to have on a table near the operator dishes containing solutions of bichlorid of

mercury in which the instruments and hands may be occasionally dipped.

I use irrigation much less than formerly, but I am very sure I have seen no ill results from the so-called chemic irritation of warm solutions of corrosive sublimate, even in strength of 1 to 1000, and I am confident that much less damage to the injured parts ensues from it than from the irritation caused by frequent sponging. When the proper technique is faultless, it is very likely that sterilized water is of equal efficiency, but my experience teaches me that the damage from the so-called chemicals, if properly applied, has been greatly overestimated. To one who is an imperfect master of technique I can not question but that the use of weak antiseptics and hot irrigating fluids is of great value.

There can be no question but that marine sponges have been a common source of wound infection, and I do not wonder that operators, who can not first supervise details, have learned to rely on the gauze pad as a substitute, since these are easily sterilized by heat during the preparation for the operation. They are, however, far inferior in their absorptive power and a possible source of conveying lint into the wound.

It is very unwise to continue the use of sponges that have been used in septic wounds, but sponges carefully disinfected may be continued in repeated use with safety in aseptic wounds. Sponges should be thoroughly washed in cold water and after repeated washings with soap and water, I prefer soaking them several days in a 5 per cent. solution of carbolic acid, changing the acid two or three times. They are then put into a jar containing this solution and kept until required for use. This process is conveniently varied sometimes by carefully bleaching in an oxalic acid solution. They must, however, be carefully watched, for if kept too long in it the integrity of the sponge is impaired. If preferred, the sponges may be dried in a muslin bag wrung from a 5 per cent. solution of

carbolic acid and kept in a sterilized jar until required for use. They should then be put into a solution of 1 to 1000 bichlorid of mercury at the time of preparation for operation.

I consider it rather disadvantageous than otherwise to delay the operation by seizing every small bleeding vessel with compression forceps. Slight pressure will usually suffice and the tissues are far less devitalized than by the use of the forceps. This careful attention to the arrest of hemorrhage is also much less important, since the closure of the wound with buried sutures acts as a sufficient hemostasis. I seldom use ligatures except for the larger vessels, adjusting the sutures so as to include all special bleeding points.

Since the introduction of antiseptic surgery, little by little the treatment of the wound *per se* has been radically changed. The drainage tube is thought far less important, although unfortunately its use is still far too frequent. It is now judged wiser carefully to coapt the wounded surfaces and by some means hold them in fixed apposition. The still too common practice is, to effect this by the use of interrupted superficial skin sutures, and hold the adjacent parts firmly in place with compression bandages. These are supposed to consist of antiseptic dressings, applied in the form of pads to serve also the purpose of absorbing deleterious wound secretions.

Nearly twenty-five years have elapsed since I began my experimental studies upon the burying of animal sutures for the coaptation of wounded surfaces and fixation of the same at rest during the processes of repair. The results of these investigations are now very generally known, and the adoption of buried animal sutures gives promise of becoming universal. The catgut suture was the first employed and almost the only material used for some years, but a much better substitute is found in the tendon of animals, preferably that from the tail of the kangaroo. In the tendons of animals the ultimate fibers are disposed

parallel to each other and in the processes of preparation the cement substance which holds them in apposition should remain unimpaired. In the connective-tissue sheath of the intestine of animals, the function of the parts demands that the fibers should be obliquely interlaced, and this sheath must of necessity be separated from the other coats of the intestine by the macerating processes dependent upon bacterial growths. When subdivided, these flat bands of connective tissue are not unlike oblique strips of the most delicately woven cloth which have been twisted into string and allowed to dry. When dry, it is comparatively firm and strong; when wet, elastic and yielding. The putrefactive processes of maceration have necessarily made it a hot-bed of bacterial growths which, beside being detrimental to its inherent properties, must necessarily be subjected to processes of disinfection. These may be satisfactory, but the resultant product does not furnish reliable material for buried sutures.

On the contrary, the tendon suture softens very slowly in watery solutions and does not swell and become yielding when buried in the structures. As a consequent, the knot, if used as a ligature, is as trustworthy as that of silk, and a tendon of the same weight and size is very much stronger. When properly chromicized, the tendon suture undergoes a very slow metamorphosis when buried in the living tissues, and weeks after its insertion, the line of suturing is easily traced. It is speedily surrounded by leucocytes and plasma cells which, little by little, invade its structure. This imbedding material is slowly changed into connective tissue cells which replace in large measure the suture material itself, thus coaptating and holding in position the sundered structures by a living bond of a permanent character.

The importance and value of these resultant physiologic processes have, for some reason, never been duly estimated, especially in the restoration of certain portions of the body, as for example, in hernia,

laparotomy and in the suturing of tendons; in fact, in any part, where undue strain is likely to supervene in the restored activities of the individual.

The application of the buried suture may be effected in various ways. Where, for instance, it is desirable to coapt and hold at rest all the sundered structures, especially if they are liable to be hemorrhagic, the double continuous suture is of great importance, double, so that the tissue may be equally and evenly included and the coaptation perfect. This is best taken with a stitch similar to that of the shoemaker in his hand-sewing with a double thread. It is my habit thus to suture the peritoneum, the aponeurotic structures in laporotomy, hernia, etc. A continuous suture has a distinct advantage over the interrupted, in that we reduce to the minimum the knots which from their undue size ever act more or less as irritants. A great advantage results from the even adjustment of the parts, since in continuous suturing the compression must be the same along the whole line of stitches.

In the application of buried sutures, it is of the first importance to remember that we do not use undue constricting force, since we are dealing with vitalized structures in which the circulation must not be unduly impaired. The same force applied to a buried suture as is to often, perhaps generally used, in the application of interrupted cutaneous sutures is very likely to be followed by a process of local necrosis, although the included tissues are aseptic.

For the coaptation of the majority of wounds, the single running suture is to be preferred, as in illustration, after the excision of the breast, the amputation of a limb, etc. I find these best applied by the use of the larger-sized, full-curved Hagedorn needles, carrying the suture deeply from side to side. In this way, coaptation is perfect, the suture is buried in undevitalized structures and crosses the wound only at right angles. It is surprising to note the apparent ease with which nature cares for numerous sutures applied in this way. They may be

used freely, but should be minimized sufficient for the coaptation of the parts, adjusting, as far as possible, like structures. Such coaptation of the divided structures leaves no open spaces or pockets to fill with blood or serum, and being aseptic, the use of the drainage tube is worse than superfluous. It withdraws from the wounded surfaces the very exudates that nature furnishes for the purposes of repair; it leaves of necessity a wound open to the extent of the drainage material applied, leaving a route for the possible access of infective material. He who drains an aseptic wound where coaptation of the sundered structures is possible, does it invariably to the damage of his patient. Fortunately, this practice is lessened each succeeding year and the time is not far distant, when, under these conditions, drainage will be absolutely abandoned.

Aseptic wounds should be completely closed at the time of operation. Referring to the bacteriologic conditions of the epidermis, it will be readily noted, what are the advantages arising from the closure of the skin itself by a buried animal suture, which I have advocated for these reasons for many years. A sharp Hagedorn needle, armed with a fine tendon should be introduced from side to side of the incision, through the deeper layers of the skin only, parallel to its cut edges. Each stitch must be taken exactly opposite the emergence of the preceding one, the emergence of the last stitch being through the skin at a considerable distance from the extremity of the wound. When the distal ends of a suture thus taken are drawn upon, the coaptation is as perfect as the seam in a well-made garment, and nothing further is required in the way of dressings, except the application of the collodion seal, which is rendered still more effective by its reinforcement with a few fibers of absorbent cotton. An aseptic wound thus carefully treated, even to the major amputations is subsequently very nearly painless, the parts are not edematous, and the collodion dressing is loosened by

the exfoliating epithelium in about ten days. The scar is minimized and is oftentimes scarcely perceptible. This fact alone is no slight desideratum, especially in the exposed portions of the body.

My own experience is now ample to emphasize this method of wound treatment which I, some years ago, first introduced to the profession. Step by step it was carried out, as the result of inductive reasoning on my part, reinforced by my experimental studies upon the lower animals. Happily these methods, which were at first critically considered, as belonging to ideal surgery, have been abundantly confirmed by the experience of many surgeons, and are now advocated as practical, yea even obligatory.

It takes rather longer to close a wound as described than by the methods still too commonly in practice. However, the work of the surgeon is finished when the patient leaves the operating table, and the subsequent nursing is minimized. Economy is subserved in the abolition of all clumsy dressings, while the danger of subsequent infection of the wound is absolutely prevented. The period of detention in bed is greatly lessened, perhaps in a large class of wounds altogether avoided, and the subsequent requisite care on the part of the surgeon and his assistants is minimized to a degree in striking contrast with that of ordinary hospital service.